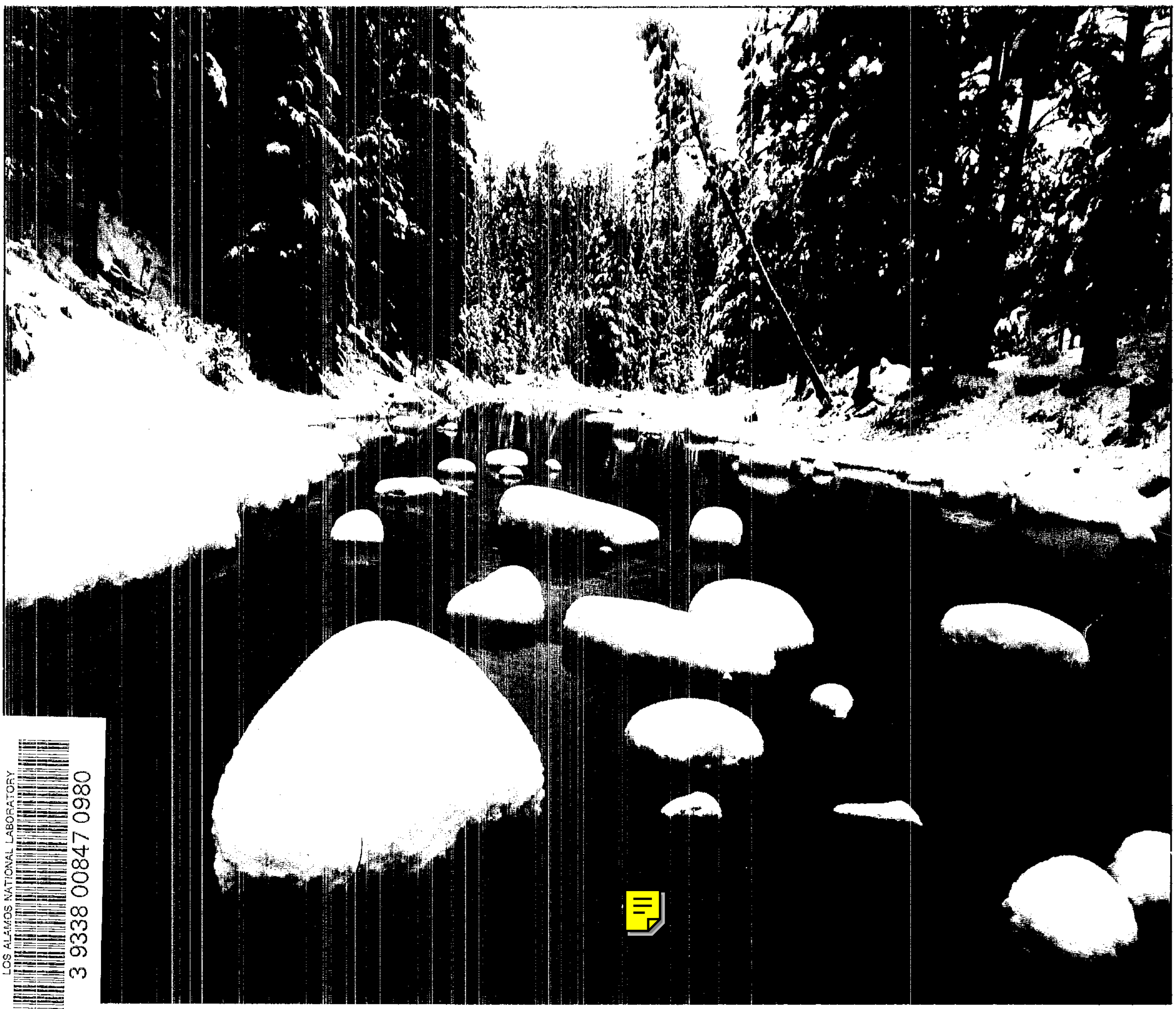
Winter 1980-81

atom

LOS ALAMOS NATIONAL LABORATORY



the muffled whispers of snowfeet...p.10

Vintage ATOM

We thought this publication, begun in 1964, had a unique name. That was until Michael Ginsberg of WX-2 brought in this vintage magazine of the same name from the fall of 1945.

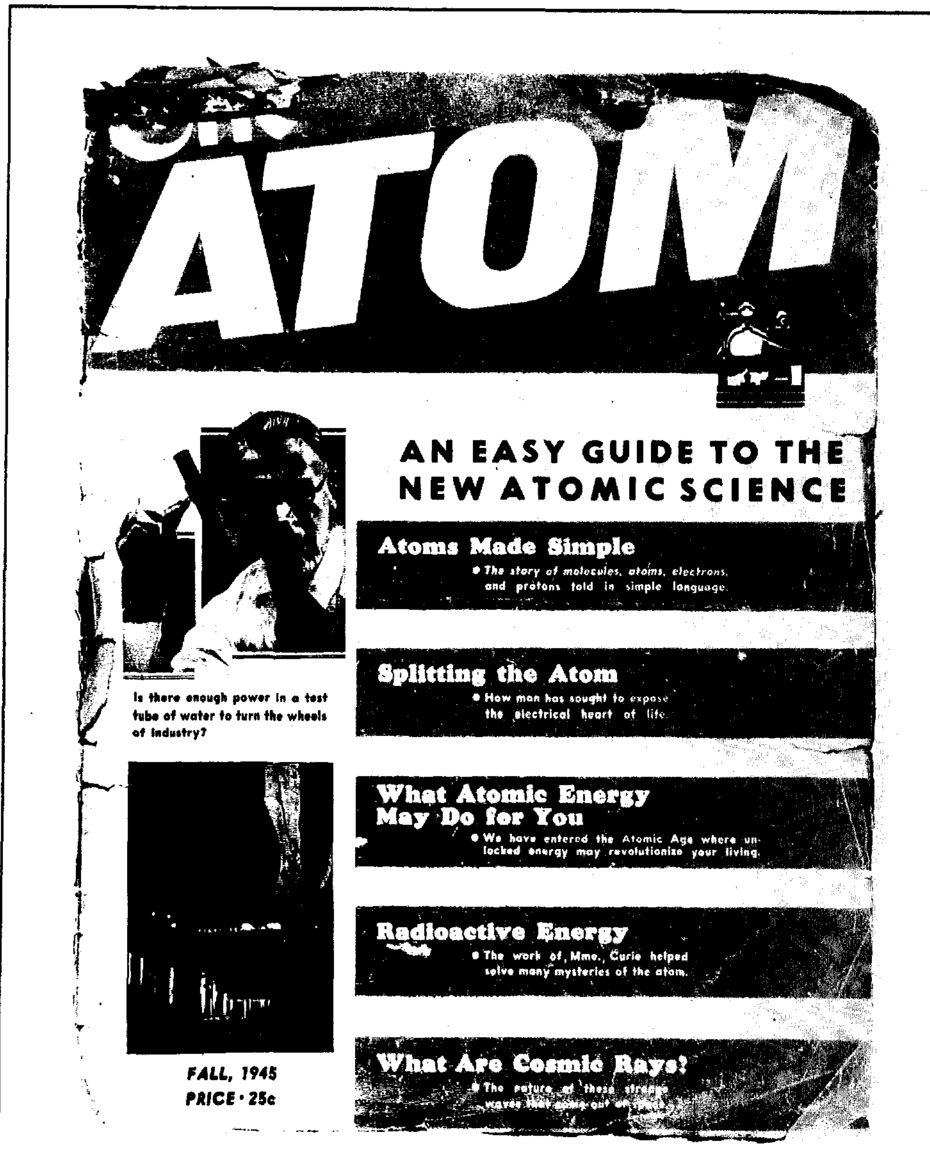
The first Atom was copyrighted by The Atomic Age Publishing Co. of Denver, and the 30-page premier issue was apparently aimed at readers ready for information about the "new atomic science." You can see some of the contents listed on the cover. Inside were aerial photos from the Army and Associated Press showing damage at Hiroshima and Nagasaki.

Other offerings included "Atomic Theory Among the Greeks" and "The Sun, Majestic Atomic Furnace."

Although future issues were advertised at three for $1, the magazine folded after its second issue in the spring of 1946, according to research by Jean Furnish at the Laboratory's main library. The editors had written that atomic science is no new fad: "It is the most portentous new fact in our lives . . . the door to a vitally new tomorrow."

In "Two Bombs That Shook the World," writer D. C. Campbell talked about Los Alamos and the Manhattan Project.

"If the atomic bomb is used in warfare in the future," he wrote, "the two bombs which ended the war against Japan will seem relatively weak and harmless . . . President Truman has said he will attempt to make atomic energy a 'powerful influence toward the maintenance of world peace.'"



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Cover photo: LeRoy N. Sanchez

The sun and the Study Center

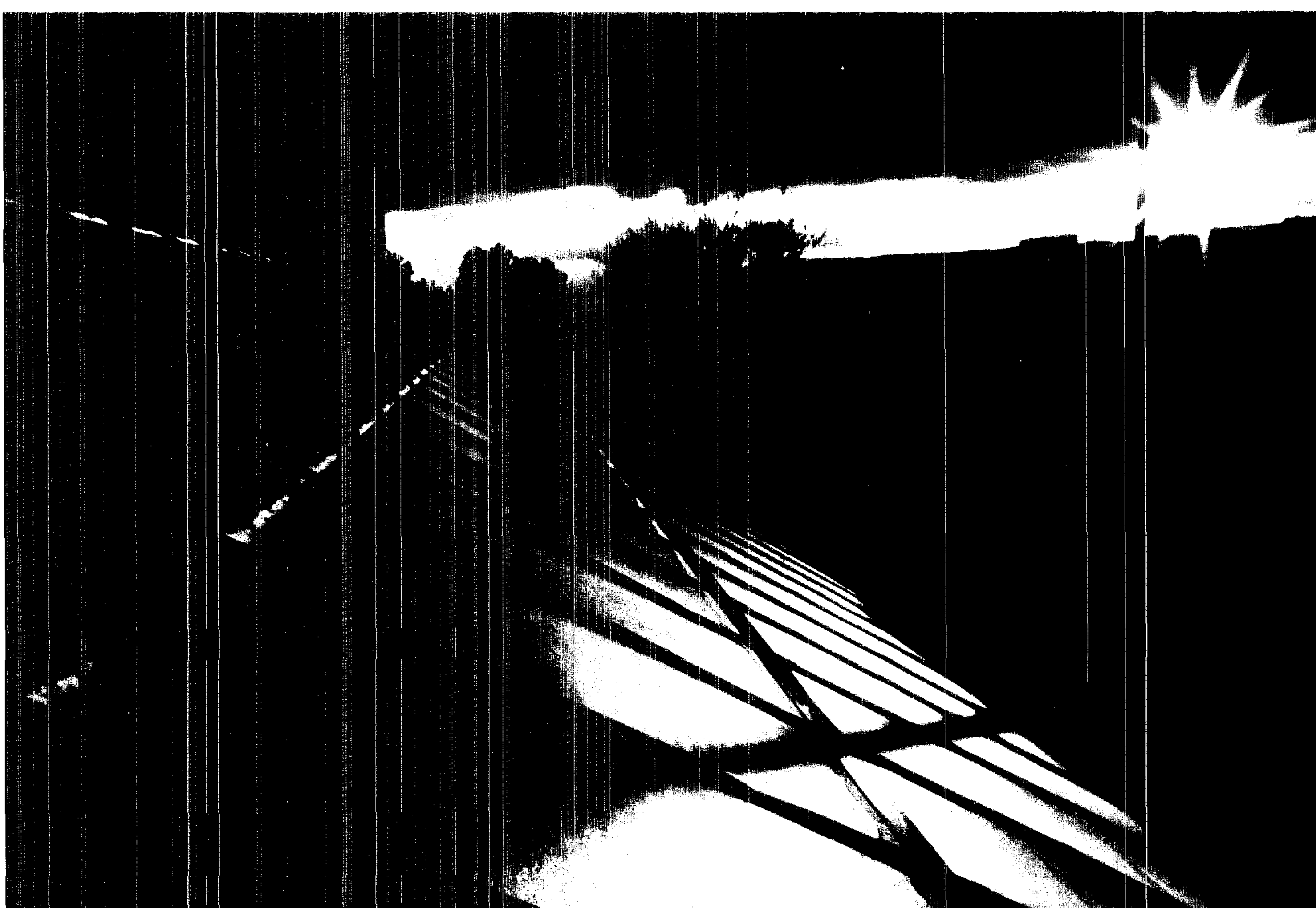
The Study Center has been used by the International Energy Agency to validate computer models.

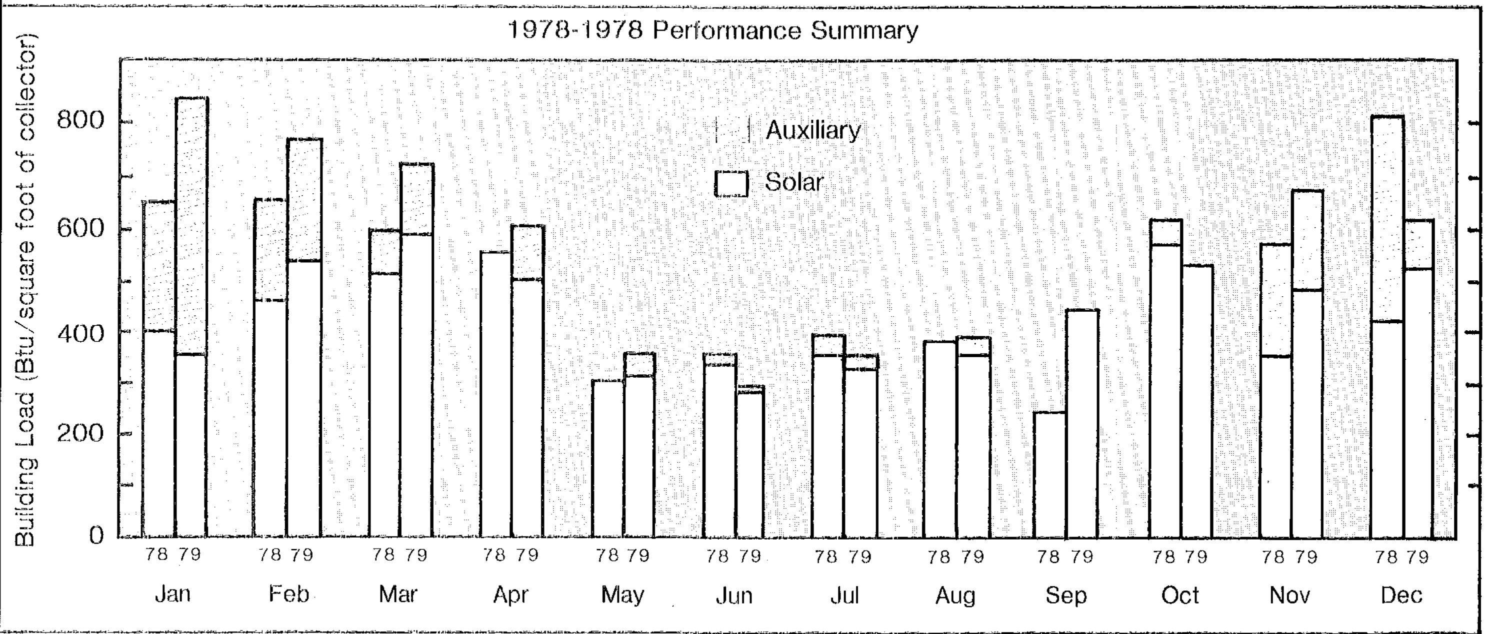
By John Ahearne

Since the Laboratory's National Security and Resources Study Center opened in March of 1977, more than 150 sensors have been monitoring the performance of the building's heating, ventilation and air conditioning system. From the wealth of data compiled over two years, researchers in the Solar Energy Group (Q-11) have completed an extensive analysis of the system, which although showing results that differ from earlier computer studies, was "neither disappointing nor exceeding expectations" and revealed a highly efficient solar energy experiment.

The performance analysis is a compilation of data gathered during calendar years 1978 and 1979, and will soon be presented in a comprehensive report written by Jim Hedstrom (Q-11) and Hugh Murray (E-11). The pair, who with their PDP-11 computer have been closely monitoring the solar energy

Sunrise at the Laboratory's solar library will be partly captured and stored. It supplies 1,272 million BTUs per year: 895 for heating and 377 for cooling. Another 293 million BTUs come from auxiliary sources.

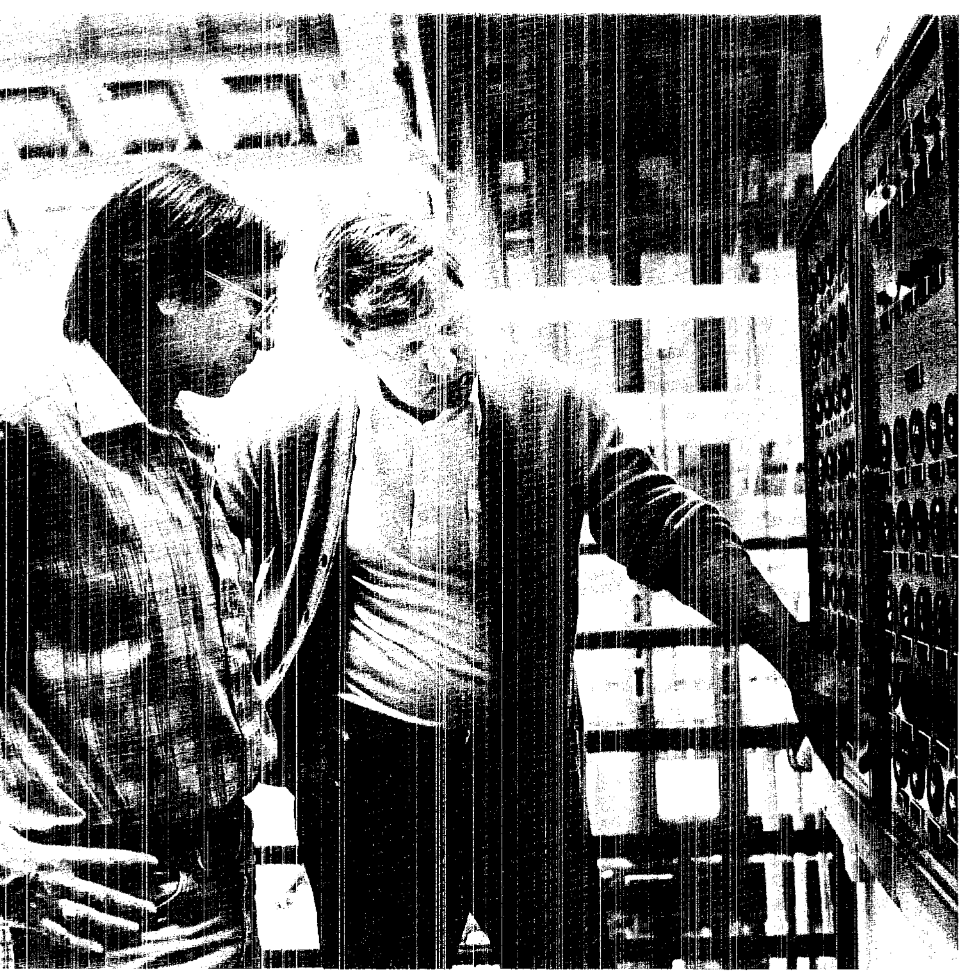




system, found that the hardware has provided 76 percent of the energy required to heat the building and a remarkable 97 percent of the thermal energy required to cool the facility.

The Study Center has a gross area of about 66,000 square feet. The lower floor contains a report library, with the main technical library of the Laboratory on the ground floor. The upper floor houses two large meeting rooms, offices, and several smaller conference areas. An enclosed concourse, which connects the upper floor with the second story of the Administration Building, is included in the spaces served by the Study Center's climate system and is contained in the analysis of the solar system performance.

The Study Center gathers its sun power from an array of 400 solar collector panels that form part of the building's roof. Each of the collector panels, two feet wide by 10 feet long, is a sandwich of glass, polyurethane foam, and steel electroplated with black chrome. The entire solar collector is 80 feet wide, 100 feet long, and faces south at a 35 degree slope. Heat energy from the sun's rays is absorbed by a light paraffinic oil which flows through the collectors then through a heat exchanger where water in thermal storage tanks is heated.



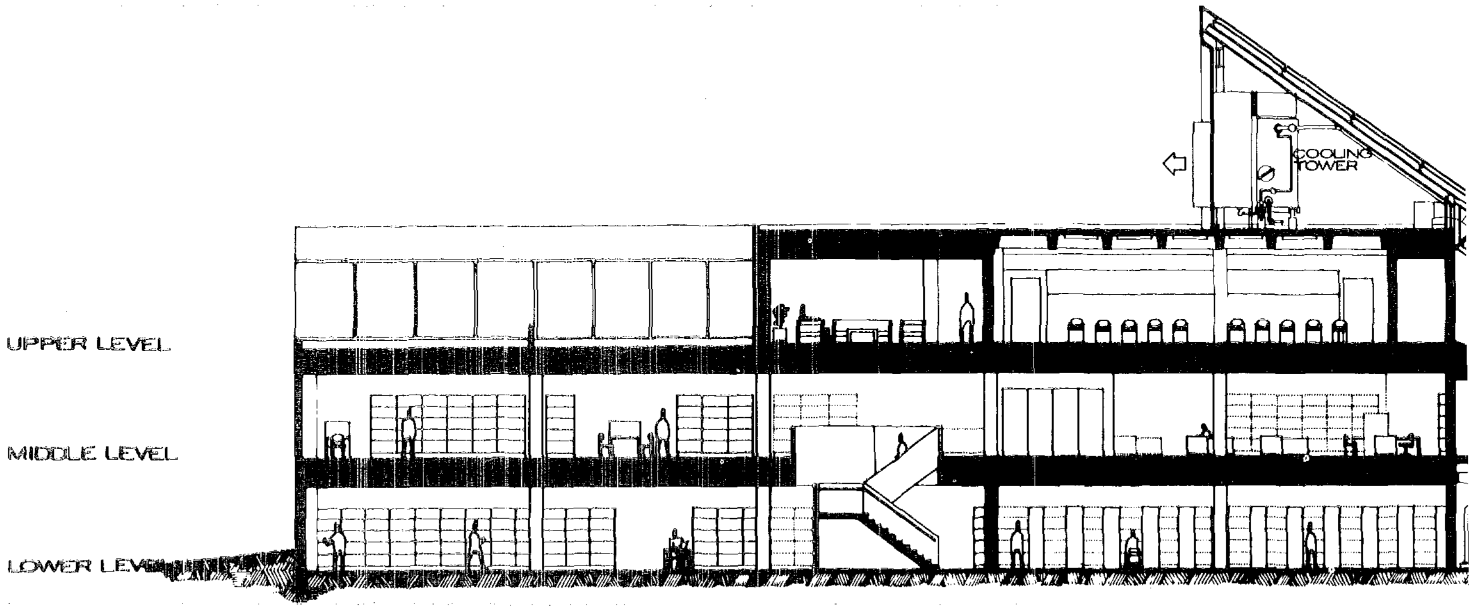
John Flower

All of the more conventional aspects of the facility's design were done with an eye toward energy conservation. The walls and roof of the building are insulated with four inches of fiber glass, and the few windows are tinted and double glazed. Even the heat generated by the light fixtures is recouped by the system with return air flowing around the fixtures and through a heat recovery unit.

During the winter, the Study Center is heated by the circulation of the hot water stored in a large 10,000-gallon storage tank. The water is heated either by solar energy or by an auxiliary steam system connected to the steam plant that services most of the Laboratory's main technical area. During the two years studied, 76 percent of the needed energy was provided by solar. The earlier computer studies had predicted 95 percent of the heating would be provided by the sun.

Two factors, however, prevented the system from attaining that high prediction. First, the addition of the concourse added significantly to the heat load of the building — perhaps as much as 20 percent. The prior computer

Hugh Murray and Jim Hedstrom, report authors, under the collectors: In 3.5 years, the system has supplied 76 percent of the heating needs and 97 percent of the cooling.



Architect: The Luckman Partnership, Inc.

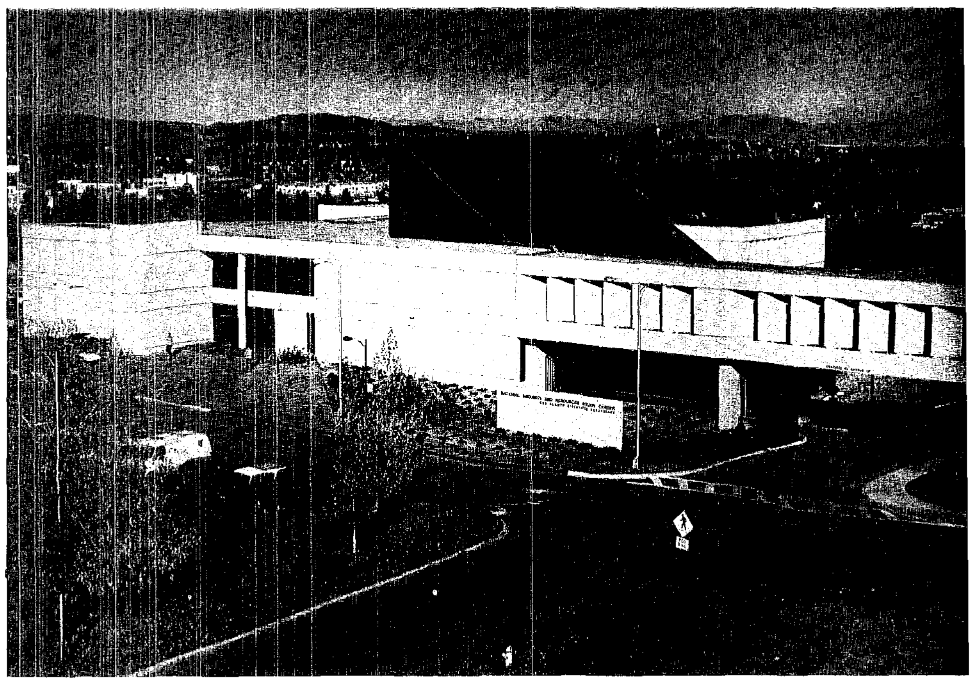
studies were completed before the decision was made to build the concourse. Secondly, the actual heating load for the two study years was higher than that modeled in the design analysis. Despite these factors, the actual numbers came close to the caliber of solar system Hedstrom says is most desirable.

"By *not* attaining 100 percent solar heating, the system becomes more economical both in original cost and in operations," said Hedstrom. He explained that a moderately priced system capable of providing perhaps three-fourths of the needed heat through solar is closer to the economic ideal: designing a system that approaches 100 percent efficiency would cost significantly more for the addition of only a few percent more solar energy.

"If you consider a graph whose axes are 'cost' and 'percent solar,' you will find that the curve levels off at around 75 percent," Hedstrom explained. "This shows that to attain higher percentages, you must spend more and more money to approach 100 percent. Economically, it just isn't worth doubling or tripling the initial cost of the system to get only a few more percent. The cost saving over the life of the solar system could never be recouped."

Hedstrom went on to say that such an efficient solar energy system is desirable in times of peak need — during the coldest days of winter or the hot days of summer — but for more temperate times such as spring and fall, the system would be overbuilt and "loafing." The designers would simply have put more into the facility than is needed on the average.

Most importantly, however, the solar system gathered in much more energy than was anticipated. The early computer studies predicted a heating requirement of 481 million BTUs annually, of which

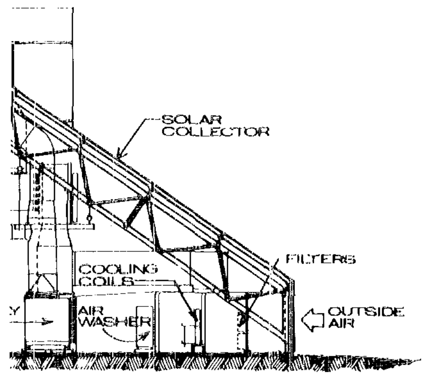


400 solar panels form part of the building's roof. Heat flows from them to an exchanger where water is stored.

464 million would be provided by the solar system and 17 million provided by the auxiliary system. In reality, the annual heat load turned out to be 1,175 million BTUs, of which 895 million BTUs came from the solar hardware and 280 million BTUs were provided by the auxiliary equipment.

"The solar system gave us much more energy than we had originally anticipated," Hedstrom said. "In fact, the system was able to convert a full 33

Above: *Plate collectors were part of the Study Center's roof. The eye-catching structure, adjoining the Laboratory's administration building, cost $4.6 million equipped.*



"By not attaining 100 percent solar heating, the system becomes more economical."

John Flower

percent of the energy available to the collectors into energy for our heating and cooling system. That's pretty good."

With the moderate summers here in Los Alamos, the solar system in the Study Center accounted for 97 percent of the thermal energy needed for cooling the facility. Two cooling systems have been installed, side by side, in the building so that Laboratory researchers could compare performance, reliability, and maintenance and operating costs. Both use solar heated water to provide energy for air conditioning.

One method uses a commercially available lithium bromide chiller that works much like the cooling mechanism in a gas refrigerator. The other is an experimental Rankine Cycle Solar Chiller, in which solar-heated water at 170-200 degrees (F) boils an organic fluid to drive a turbine connected to a conventional air-conditioning compressor. On an average for the two cooling seasons studied, the solar energy system annually delivered 377 million BTUs of a needed 390 million BTUs. Only 13 million BTUs were required of the auxiliary system.

Another measure of the Study Center's solar cooling operation is the "coefficient of performance," which is the ratio of the cooling energy provided by the system to the electrical energy put into the system. For the Study Center, this ratio is 3.3 to 1. Most conventional systems operate at about two to one in this respect, and most solar cooling systems today have an even lower ratio.

The Study Center is a key element in the nation's solar energy effort. It provides a well-designed, properly functioning and thoroughly analyzed benchmark for assessing the effectiveness of this type of solar heating and cooling system in office buildings. It is probably the finest example of this energy-saving approach to be found in the U.S. Furthermore, it has been used by the International Energy Agency's solar heating and cooling program for the validation of computer models.

The extra cost of installing a solar energy system into the Study Center will be more than paid for during the lifetime of the facility, as non-renewable fuels will not have to be purchased. Over this period, the Study Center's solar energy system will save the equivalent of 13,000 barrels of oil.

The Study Center and its solar system is open to the public.

From "Chemica Scripta" to "Optica Acta" and beyond, the journal reader will most likely find his or her publication in the Laboratory's technical library. Owned by the Department of Energy, it has an area of 66,000 square feet.

Touring the **Tewa site** at Phermex

To the untrained eye, it is only an undulating mound. To the expert, it is the work of ancestral Tewa Indians.

By Jeff Pederson

An unassuming mound of bricks cut from volcanic rock has lain at one of the Laboratory's remote testing sites for about 500 years. To the untrained eye, it might appear only as an undulating, brush-covered mass, perhaps scraped together by a bulldozer some years ago.

To Edgar Lee Hewett, however, the 10-foot-high mound was obviously the work of ancestral Tewa Indians, who left their marks all around the Pajarito Plateau. Hewett, former director of the Museum of New Mexico, described the plaza village before the turn of the century, and he included it in his archaeological report of 1906.

Today, the plaza, still unexcavated, is intact. Within a third of a mile lie two other satellite villages; perhaps up to four other satellites have been destroyed by the frenetic pace of World War II construction in Los Alamos.

Twentieth century visitors had a chance to see "Phermex Site," named after a modern facility that makes flash X-ray pictures nearby. In October, the fourth archaeological tour to Indian sites on Laboratory land, and open to the public, was held. With two buses running each hour from the Administration Building, 500 employees and visitors were able to see what is also known as "Site LA-4665," which lies behind a security fence.

"Only a mother could love this site," said Laboratory consultant archaeologist Charlie Steen, who was on hand for five hours to explain the unseen configuration of the plaza village and a stone shrine, found a few hundred yards away on the brink of the steep south-facing wall of the Canyon del Valle. Indeed, it takes some imagination and an experienced eye to imagine Indian life of five centuries ago.

The plaza site itself sprawls about 60 yards across, measured east-to-west, and

Above: *Plaza site, still unexcavated, lies high a[t] 7,300 feet on the Pajarito Plateau. It contained buildings of two and three stories.*

"Only a mother could love this site."

a little more than that on the north-to-south axis. To the east were 2-story buildings; structures on the west rose to three stories. In between was a large plaza, no doubt used for communal activities that included food drying and cooking, the working of animal skins and bones, and the preparation of stone and wood implements.

"Surely they must have been dry-farming the mesa top," said Steen. Modern construction from the war has disturbed the surrounding terrain to such an extent, however, that soil samples that might indicate corn pollen are not of use. Other agricultural activity around the Pajarito Plateau is well documented.

Of the dozen plaza sites recorded on Laboratory land, not all are contemporaneous in time, but fall within a rather restricted time period. Phermex Site was inhabited in the late 14th and early 15th centuries, judging from the decorative Abiquiu Black-on-Grey and Bandelier Black-on-Grey pottery types found. Not much later in the Tewa history would come the significantly larger towns of Tyonyi, Tserige and Otowi. The common corrugated pottery shards found at Phermex Site and elsewhere are worthless as dating tools, Steen explained, because they were used in the same forms for hundreds of years. A few earlier Wiyo shards have also been found.

Probably only a few dozen people lived at Phermex Site. An underground ceremonial room, or kiva, must certainly lie in the main central plaza. Outside the eastern rooms, two other kivas may exist in two smaller plazas. One can only speculate from how far other Tewas may have come for ceremonial activities.

Rooms at Phermex Site are smaller than at other plazas, and measure about five by 10 feet. The Tewas most likely built one-story dwellings first, then added second or third stories as needed. In time, the lower rooms were probably used as refuse receptacles or as places to bury the dead.

Mesa fir trees up to eight inches in diameter could have been cut easily enough with stone axes and used as roof poles, said Steen. When the Tewas needed trunks of larger diameters, they held burning coals to them until the pieces parted. Beams four to six inches in diameter would have been adequate for ceilings at Phermex Site, and perhaps an excavator of the future would find ax-chopped poles that looked "as if a beaver had attacked them."

Two persons on tour in October pointed out new artifacts to Steen. One was a maul, made from local basalt. The other was a well-made granite stone ax, perhaps taken from Rio Grande formations or perhaps brought from farther away.

Phermex Site lies at what was probably the upper limit of farming on the mesa, 7,300 feet. Only two other sites, both small, are found at a higher elevation

Below: *"Surely they must have been dry-farming the mesa top," said archaeologist Charlie Steen, who later inspected a stone maul and an ax spotted by two persons on the tour.*

Probably a few dozen people lived here. Nearby were small satellite villages.

on this particular mesa. One is a quarter mile west and the other is near the Group M-2 office building.

The shrine that may be seen above the nearby canyon is probably not of the same time period as Phermex Site. No pottery shards of any kind have been found there, and only guesses can be made regarding the use of the four or five concentric rings of upright stones that lie under the spreading branches of a juniper.

"Why would the Tewas make a large shrine there when they already had a ceremonial plaza site nearby?" asked Steen rhetorically. The stones are devoid of any markings or petroglyphs. Aside from knowing that Indians frequently located shrines at points or overlooks, little more can be said about the concentric rings at this time.

If past turnouts are any indication, the public tours to archaeological sites — first suggested by the Department of Energy's Los Alamos office as a public service — have been popular. In addition to the 500 persons who toured Phermex Site, there were 250 counted at a tour to Nakimuu in 1979 and 1,500 at Cave Kiva earlier this year. Behind the tours, and unseen by the participants, are hours of behind-the-scenes preparations.

"Afterward, you breathe a sigh and are glad that everything went off without a hitch," said Verna Halloran of Group H-8, who works with Steen and others on the logistics end of things. An information letter is first sent to about 13 people within the Protective Force, the security office, the public affairs desk and the Department of Energy, she explained. The dates, the plans to enter security

Above right: *"Why would the Tewas make a large shrine there when they already had a ceremonial plaza site nearby?"*

Above left: *Bricks cut from light volcanic rock, or tuff, formed walls that supported earth-covered poles. Rooms at "Phermex Site" were relatively small and measured five by 10 feet.*

Nearby is a shrine of several concentric stone slabs. Its use must remain speculative.

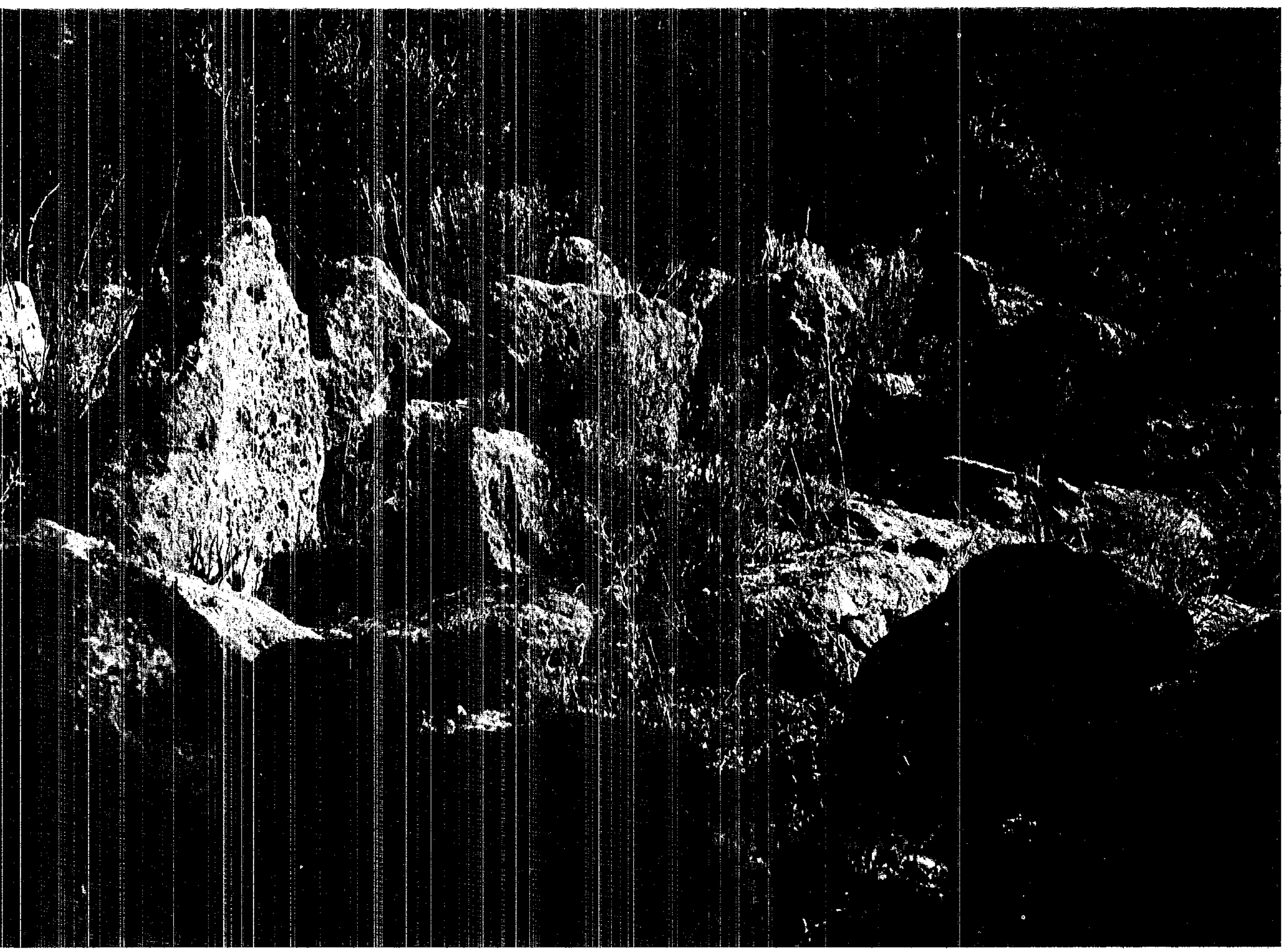
areas, the number of buses and visitor badges and escorts needed, are all spelled out. Volunteers agree to be guides, and 28 were needed for the Phermex Site tour.

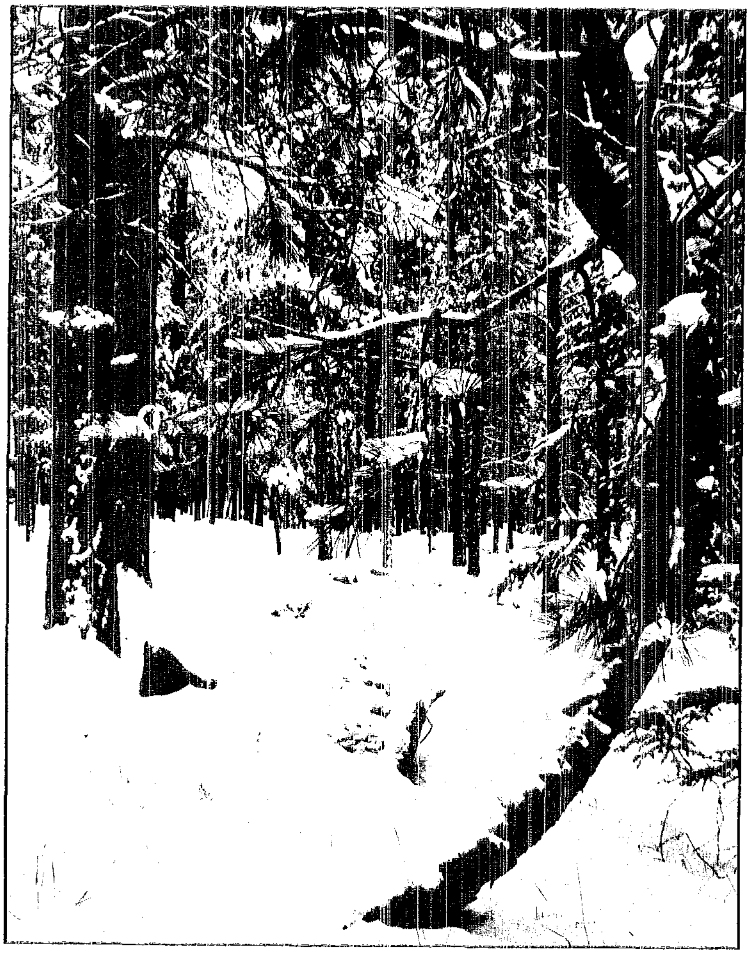
A first aid station in a truck is always available during tours, and radio contact is maintained with Protective Force guards while visitors are behind security fences. Don Van Etten can always be seen manning the first aid post, and H-8 group leader Wayne R. Hansen is found during tour days lending his help either at the rendezvous point or at the tour site.

The tours, Halloran explained, have all been conducted without incidents, and plans are being made for another visit to an archaeological site this spring. The cost to the government, compared to the pleasure given to hundreds of persons, remains very low.

Modern Tewa legends indicate that the ancestors of Indians who now live in nearby pueblos once occupied the Pajarito Plateau. Visitors will have another chance to visit some of those sites next year, and possibly to name them as well. The Nakimuu ruin received its name last year on the suggestion of an employee. Perhaps Phermex Site will fare as well, if an appropriate idea is forwarded to Steen at Group H-8.

***Below:** A shrine of concentric stone slabs overlooks the Canyon del Valle. Since no pottery shards have been found there, its date is unknown.*





Snowfeet in **the Jemez**

Photos by LeRoy N. Sanchez

Snowfeet

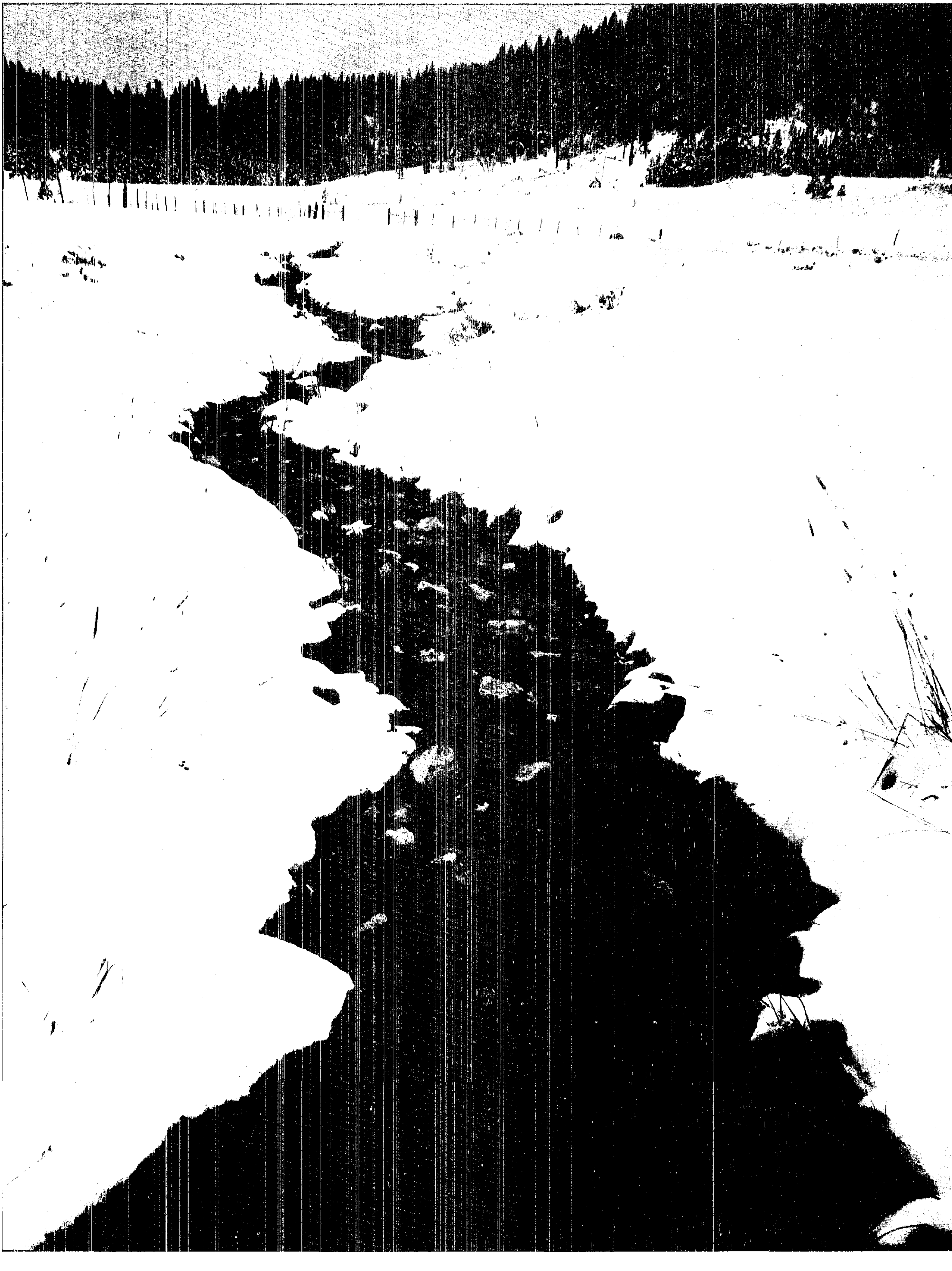
Hush, shuffle slowly
Now, listen closely
To muffled whispers
As you walk with snowfeet.

Only glimpse remnants
Of autumn's golden charge
Lying mute, blanketed
Where you walk with snowfeet.

Hear the burdened firs
Bending, the wool sky
Murmur thickly,
As you walk with snowfeet.

Crackle will crisp ice
When crystal mates
With flake. Wondering,
Now you walk with snowfeet.

—JLP



Emilio Segrè on the neutron

"Around 1930 there was a big change in physics," understated scientist Emilio Segrè, whose work in Italy led to an important position in Los Alamos during the frantic World War II days. Since quantum mechanics had essentially been completed about 1928, he said, younger physicists looked toward the atomic nucleus as a somewhat unknown target for their inquiries.

Ernest Rutherford of England had speculated on the properties of a neutron, but was unable to experimentally find the particle with electrical charges designed to collapse a hydrogen atom. Other interest in the topic continued in France, Germany, and Italy, with about 100 experimenters. In the U.S., the trend in physics was toward machinery.

"They were not . . . particularly versed in nuclear physics," said Segrè of the Americans as he addressed a Young Scientists' Invited Lecture Series audience here, sponsored by the meson facility's users group.

Rutherford had found he could disintegrate light elements by bombarding them with alpha particles. In particular, he observed that protons were emitted. Were gamma rays emitted by beryllium that underwent alpha bombardment? Walther Bothe, a German physicist, tried experiments with a polonium source. He counted the gamma energy, then interposed pieces of lead between the source and the target. Measuring the energy coefficient in lead, he came up with six million volts.

Among those repeating this experiment were Irene Curie, a scientist well-trained by her mother Marie, beginning with X-ray tests run on soldiers in World War I. She was to collaborate extensively with Frederic Joliot, whom she married, and who produced the strongest polonium source then known in the world.

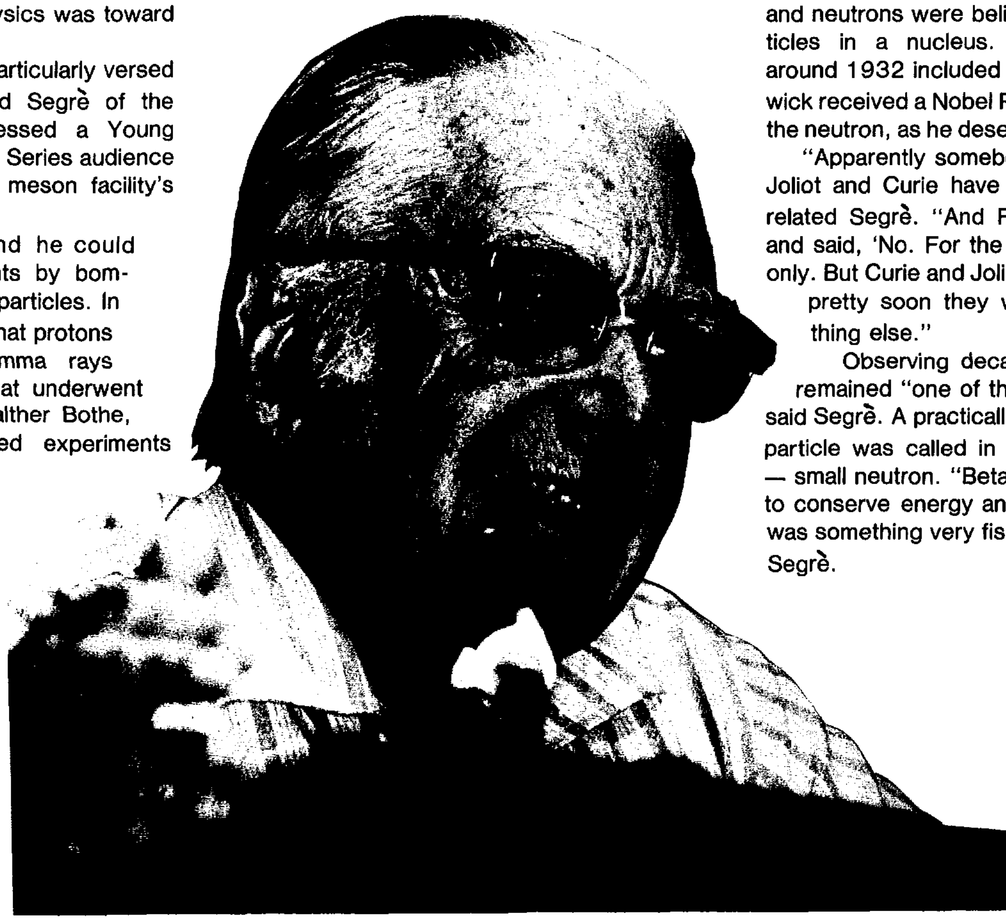
"A strong source may see things that 10 weak sources cannot see," said Joliot-Curie, who didn't want to fraction this source. He and his wife found that ionization increased when hydrogen was introduced into the experiment, so they interpreted the gamma rays as protons in January 1932.

One young physicist said of their conclusion: "These idiots . . . they have discovered the neutron-proton and they don't recognize it." In England, James Chadwick said the Joliot-Curies had discovered the neutron particles that he and Rutherford had looked for.

A new nuclear model came to be established. Segre had learned early in school that an atomic nucleus was formed by protons and electrons, but now protons and neutrons were believed to be the particles in a nucleus. Other discoveries around 1932 included the positron. Chadwick received a Nobel Prize for discovering the neutron, as he deserved.

"Apparently somebody said, 'Well, but Joliot and Curie have also some merit,'" related Segrè. "And Rutherford objected and said, 'No. For the neutron, Chadwick only. But Curie and Joliot are so clever that pretty soon they will discover some thing else."

Observing decay of beta particles remained "one of the great mysteries," said Segrè. A practically undetectable new particle was called in Rome the neutrino — small neutron. "Beta decay didn't seem to conserve energy and momentum; there was something very fishy about it," related Segrè.



"This really changed the face of nuclear physics"

By the end of 1933, Curie and Joliot had observed that after bombardment, positrons kept appearing, without a source. They had found artificial radioactive elements.

"So this was a very collosal discovery, a fundamental thing, that really changed the face of nuclear physics," said Segrè. "And finally, this time, they had really discovered it; they hadn't missed it!" The elder Madame Curie, then quite ill, visited her daughter's laboratory and was "out of herself with joy."

In Rome, Segrè and four others began in March of 1934 to bombard a host of elements, using neutrons to generate artificial radioactive substances. "Our neutron source had radon pumped with beryllium, in a piece of glass," Segrè related. The device would have fit into a pocket, he added.

A counter determined the electric charges of emitted particles, to make sure they weren't positrons. A simple ionization chamber, developed in Rome, was later used at Berkeley.

Uranium was a difficult substance to work with because of its natural radioactivity, said Segrè. "We had to purify it and work very fast in a limited amount of time. It was technically difficult." The team could distinguish several radioactive periods of decay but was thrown off the correct track for a time by holding to a false theory of the composition of certain elements. Segrè and a colleague visited Rutherford in the summer of 1934 in Cambridge.

Back at the Rome lab, "it started to be like there were miracles happening" with bombardment experiments. Enrico Fermi thought they should filter the neutrons through lead and paraffin. With the latter, one could see activity multiply by 10, said Segrè. Fermi said, on Oct. 22, 1934, that the neutrons were slowed by collisions through the paraffin and then became more energetic. This was a revolutionary idea at the time.

"There were many things . . . which fell into place, practically within one day," Segrè recalled. Team members took patents on the slowing down of neutrons, on the advice of others. By the end of 1935, with the political situation in Europe disintegrating, the team was disbanded. Fermi developed his theory on "the motion of neutrons in a hydrogenous medium" and became the foremost authority on neutron behavior. He later led the team that achieved the world's first sustained atomic reaction under Stagg Field at the University of Chicago in November 1942.

In 1938, fission was discovered in Germany. "The idea of a chain reaction came naturally to many, but not that many acted on it," said Segrè. Some people took out patents, but they covered only ideas, since no process was described. One needed to yet know how many neutrons are emitted per fission, what spectra they had, what the fission cross section was, and what the absorption cross section was, before any application could be made.

Neutrons were important for an atomic chain reaction, whether to create civilian power or to build a bomb, said Segrè. A study in Berkeley on how to make a bomb led to the creation of the secret Manhattan Project and the undercover town of Los Alamos.

Persons interested in additional reading should start with the Smyth Report, said Segrè. "It's still about the best."

Emilio Segrè received his Ph.D. in 1928 from the University of Rome and worked with Enrico Fermi and other scientists during the next decade, when the bases for producing nuclear power were laid. In 1938, he left Italy for the University of California at Berkeley's radiation laboratory. He worked on the Manhattan Project at Los Alamos 1943-46 when the first atomic bomb was designed and constructed. In 1959, Segrè received a Nobel Prize for his role in discovering the anti-proton, along with Owen Chamberlain. A fellow of the Guggenheim, Rockefeller and Fullbright Foundations, Segrè has since 1972 been emeritus professor of physics at the University of California.

—JLP

Above: Artist's impression of Segrè at that exciting time. Illustration by Gail Flower.

Left: Emilio Segrè said this fall that Americans were not particularly versed in nuclear physics in the 1930s. Photo by Patti Wolf, courtesy of the Los Alamos Monitor.

The image enhancers at M-5

Blurred photos a dull subjects — until Scotland Yard is interested.

By Jeannette J. Mortensen

The striking results achievable by restoring an image with computer processing is familiar to anyone who has compared the before and after photographs of Saturn, Venus, Mars and the moon telemetered to Earth from space satellites.

Image restoration means constructing an ideal or improved image from a poor one, such as restoring an old, faded photograph to its original condition. Image enhancement never adds information to a photograph, but it can make it more visible. The latest sophisticated restoration techniques rely on computers to eliminate imperfections, so that the enhanced image looks as if it had been taken under optimal conditions with a *perfect optical system.*

The major role of the Laboratory's image enhancement group originally was to support the weapons effort by clarifying images of experiments conducted at the Laboratory's Phermex (Pulsed High-Energy Radiographic Machine Emitting X-Rays) facility. As the Laboratory's mission expanded into non-weapons research areas, work conducted by the image enhancement group also diversified.

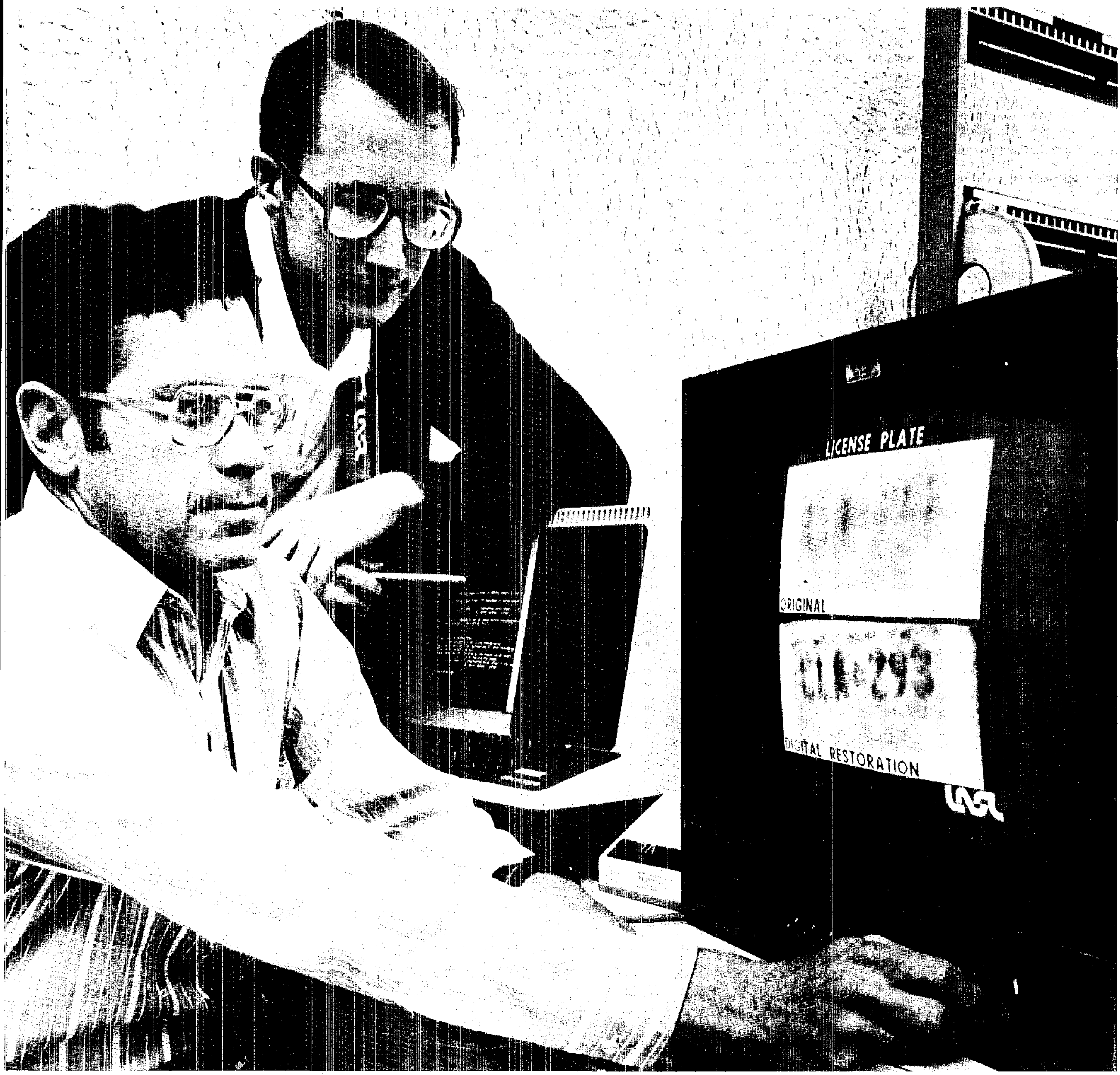
Today, under the direction of Don Janney, the Materials and Image Evaluation group (M-5) still works on Phermex radiographs. But in addition, group members apply enhancement techniques to medical X-rays, photos of solar eclipses, computer axial tomography scans, images of laser fusion targets and blurred film. Image "deblurring" and coded aperture imaging are names given to two of these exciting areas of development in image restoration.

Hocus Pocus, Get in Focus

Several years ago, when first questioned why anyone would want to develop the capability of focusing blurred photographs, Mike Cannon, a staff member in what is now M-5, responded with what seemed at the time a far-fetched scenario.

"Suppose," Cannon began, "that suspects were speeding away from a crime and someone took a picture of the getaway car's license plate, but when the photo was printed the plate was illegible. Case closed."

Last year much of that hypothesized scenario came true. Cannon and coworker Joel Trussell, now with North Carolina State University, had the opportunity to put their special talents to work for Scotland Yard — sharpening the



LeRoy N. Sanchez

details in an out-of-focus photograph of a license plate.

Although British officials have not released all the details because the case is still pending, Cannon has learned a little of the background.

In a parking lot in England, a guest snapped some photos of a wedding party as the bride and groom departed. Detectives later learned that a car parked in the lot at the time of the wedding had been used in a bank robbery.

But they needed the license number to proceed further. Unfortunately, the plate was outside the depth of field, too blurry to be read.

So Scotland Yard called on the Laboratory for assistance. "We're known all over the place," Cannon said.

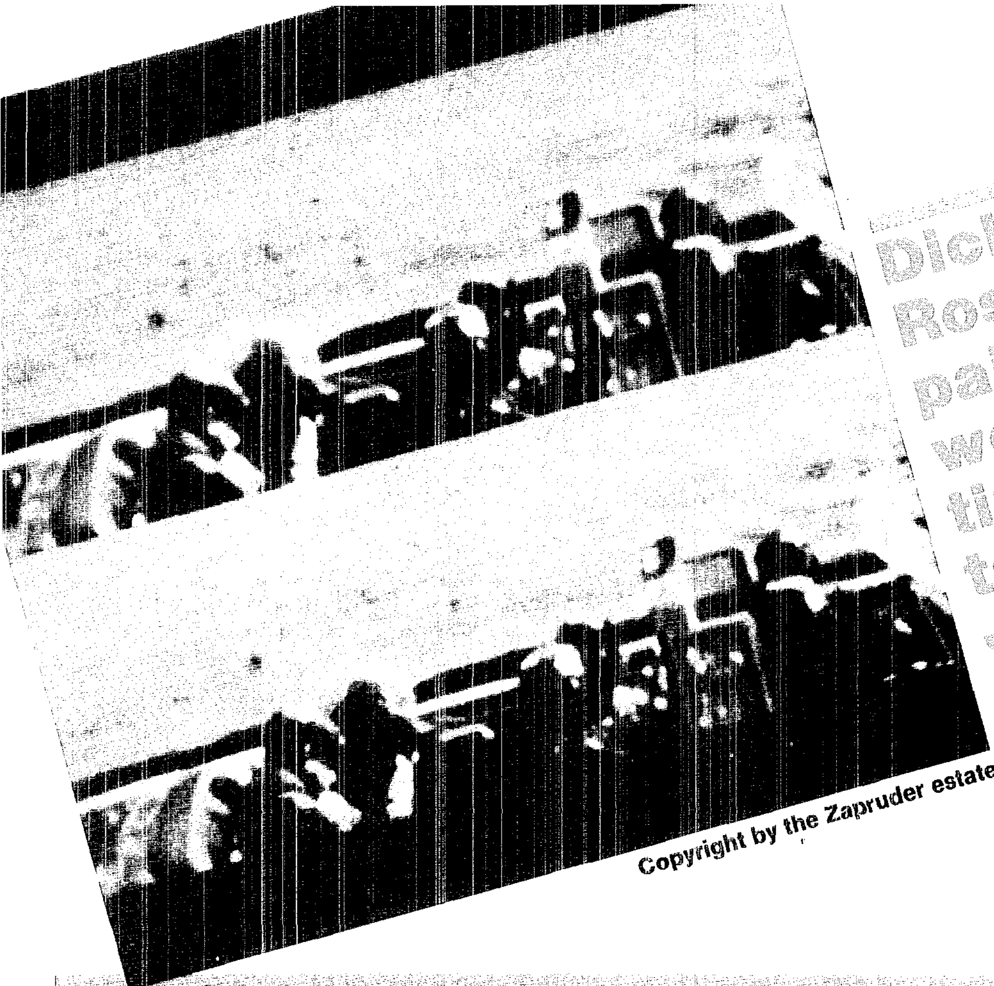
The image of the plate on the 35mm color negative film was less than a millimeter long, and enlarging it didn't help. "All of the grain structure of the film kept building up on us," said Cannon. But his computer program along with the group's sophisticated image reconstruction equipment allowed the Holmes and Watson team (Cannon and Trussell) to focus in on the wanted plate numbers. By restoring the red and green components of the film, the black letters and numbers on the yellow plate became visible.

EKE 931 K.

Working in their spare time, Cannon and Trussell completed the work in about three weeks. "It could have been done in a day," Cannon said, "but it was strictly a back-burner project."

He mailed the enhanced photo back to his contact at the Yard, and in a week or two learned the results of the sojourn into the world of police work. Dr. Alex Lehar, Police Scientific Development Branch, telephoned Cannon to say that

Above: *To practice sharpening blurred photos, staff members at M-5 took an out-of-focus picture of a New Mexico license plate. Jim Breedlove and Mike Cannon show how computer restoration yielded a readable version.*



Dick Bagley and Rosemary O'Connor painstakingly worked with tiny frames taken of John F. Kennedy's assassination.

the enhanced photo "led us to a group of people known to be associated with such dealings in the past."

Lehar must have been impressed with the results because he has persuaded Cannon to work at the British Home Office — in their new image enhancement laboratory — for a year's sabbatical. Cannon leaves for England next May.

Now You Don't See It, Now You Do

Cannon and Trussell followed a basic three-step procedure to focus the license plate photo. The same basic procedure is used to clarify images of weapon tests, solar eclipses, comets, planets and medical X-rays.

First, the image — usually a photograph or an X-ray — is scanned line by line by a microdensitometer. The Laboratory's densitometer is a mammoth machine that weighs about 4,000 pounds. Its base, rails, and large C-shaped yoke (about 400 lbs) are made of granite. When you're working with equipment at accuracies of one micron (30 millionths of an inch), you want it to be unshakable.

The microdensitometer can scan images ranging from 14 by 17 inches to an 8mm frame of film. Moving along at 55 centimeters per second (1 mile per hour), it can sample as many as 3,600 points in one horizontal pass as the table, on which the photo or film rests, rolls back and forth under the scrutinizing lens. After each pass, the densitometer's arm advances 1 to 400 microns, then scans a new line. Dick Bagley, who operates the machine, says at this rate, it takes about an hour to complete a 14 by 17 inch radiograph.

The next step is to try to determine what caused the blur. Was it vertical or horizontal camera motion or an out-of-focus lens? Once researchers determine the type and amount of "smear," they can write algorithms, in the form of computer programs, to correct for it. "The algorithm for deblurring images is sufficiently new," says Cannon, "that not many other labs in the world have the capability."

An algorithm is a set of repetitive mathematical operations, which, for example, tell the computer to adjust a number that represents the intensity or density of the photo at a certain point called a pixel (*pic*ture *el*ement). Because thousands of such alterations must be made to enhance an image, a large, fast computer is needed to handle all the operations in a timely manner.

When asked how a researcher selects an algorithm that will achieve the desired results, Jim Breedlove, associate group leader, responded.

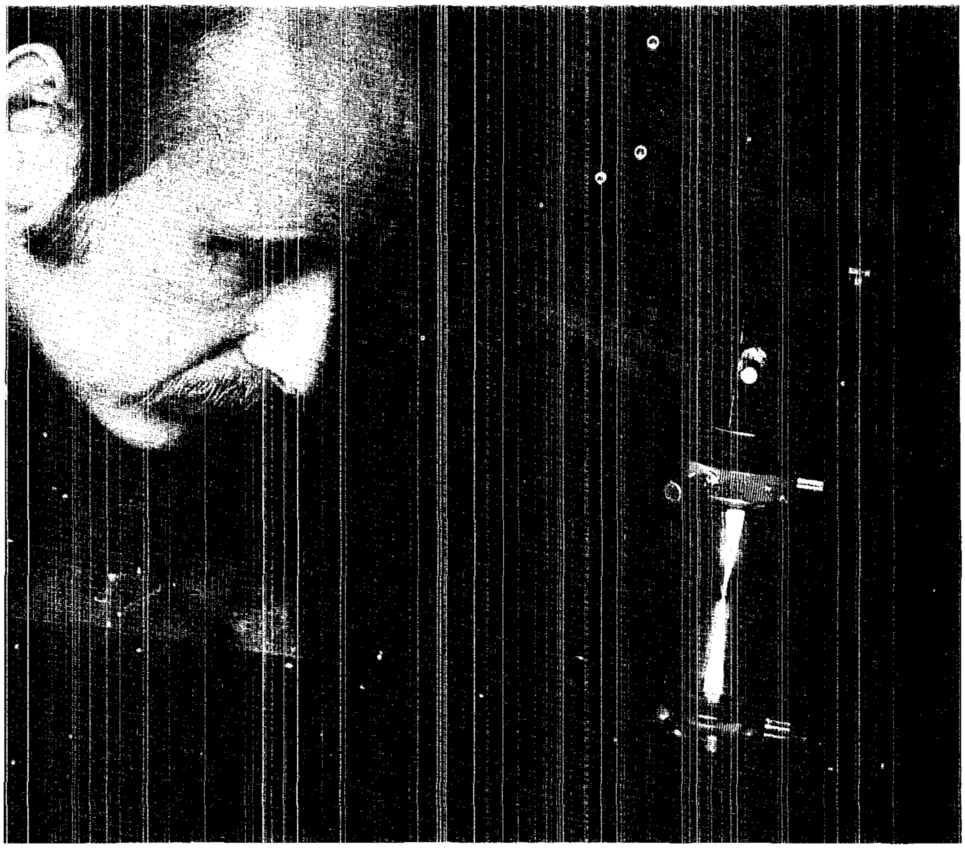
"What we generally do is work cafeteria style. We have a number of dishes, and we take one from here and one from there. Another way to look at it is as a bag of tricks. We see what worked before and vary the parameters to fit the situation we're dealing with."

A digital computer reads the tape of numerical readings taken by the densitometer and makes alterations according to programs written by M-5 staff. "Often numbers higher than a specified amount are multiplied by a factor greater than one while lower ones are multiplied by a factor less than one," explained Breedlove.

The effect of this enhancement process is an increase in detail at the expense of the overall gray tone of the image. The process is somewhat analogous to the bass adjustment on a stereo, just as the control knob allows the listener to beef up or tone down the low notes.

One technique, called "histogram equalization," said Breedlove, "reassigns densities to use the full range of the output medium." The computer produces a tape with new density values, which is used to reconstruct an enhanced image

***Above:** One of 16 restored frames of the Zapruder movie, originally in color.*



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on M-5's image processing system. The image is reformed, line by line on a TV screen, in color or black and white. A Polaroid or 35mm camera hooked up to the system can capture on film the image that appears on the screen.

The resulting image has much sharper detail and better defined edges. And for researchers who must take accurate measurements from images, clarity and sharpness are essential.

Standard "off-the-rack" processing can produce striking improvements in a photograph, but tailoring the process to a specific image can often yield even more dramatic and useful results. Sometimes the enhanced photo brings forth details totally invisible on the original, as in the license plate photo.

Sharpening the Tools to Sharpen Photos

The license plate project was not the first and undoubtedly will not be the last conducted by LASL for a criminal investigation. Group members applied their techniques to film of another crime in 1977, when the group was commissioned to improve some motion picture film shot by Abraham Zapruder of John F. Kennedy's assassination. The objective was to correct for a blur produced by the home-movie camera to make it easier for investigators to discern faces and the exact positions of those in the President's limousine.

For this work the group was reimbursed by the House Select Committee on Assassinations. Dick Bagley and Rosemary O'Connor did the painstaking and time-consuming job of digitizing 200 frames of tiny 8mm film and restoring 16 of them. The computer tapes that compensated for the wobble are now in permanent storage in the National Archives.

"What we did with the Zapruder film was very subtle and does not necessarily reproduce well," said Breedlove, who was involved in some additional photogrammetry (the science of extracting information from pictures) for the Select Committee while analyzing photographs of the crowd on the grassy knoll. "We often undertake exploratory projects for other agencies," he said, "just to keep in practice."

When group members aren't working on projects for Scotland Yard, select Congressional committees, or other Laboratory divisions, they may occasionally be seen in a Laboratory parking lot taking out-of-focus shots of license plates. "We don't get all that many photos to sharpen, and we need to keep our tools honed," Cannon explained.

Coded Apertures — Many Holes Make Light Work

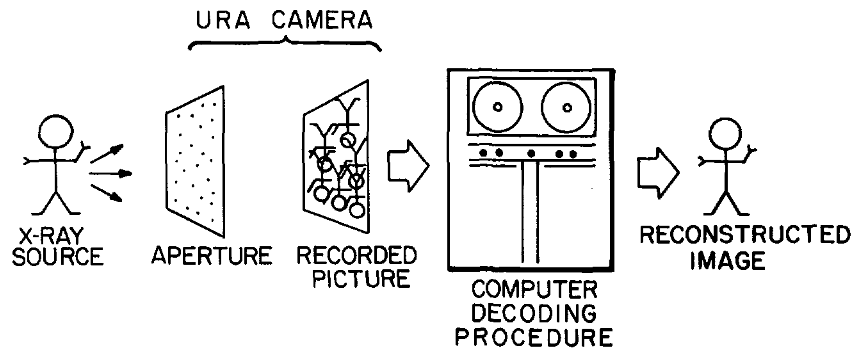
X-rays are used for everything from detecting cavities in teeth to probing mysterious black holes in outer space. But one obstacle to extracting information from X-ray images stems from the optical properties of the rays.

Unlike ordinary light, X-rays cannot readily be reflected with mirrors or be bent by lenses. One instrument that can be used to image X-rays is the single pinhole camera — similar to the simple ones many school children make from outmeal boxes to view a solar eclipse.

But when trying to image objects smaller and fainter than the sun, a conflict between the requirements of a small hole to obtain good resolution (a factor of how well objects can be distinguished) and a large hole to gather a strong enough X-ray signal tends to limit the usefulness of images produced with a pinhole camera.

In the early 1960s, two researchers in the field of optics came up with a solution. Faced with the prospect of having to image faint celestial X-ray sources, they saw the need for a camera with a large aperture, high resolution and

***Above:** Images are scanned line by line with a microdensitometer, as Dick Bagley of M-5 illustrates. The whole machine weighs about 4,000 pounds.*



New cameras with special patterns provide high resolution and do not produce "ghosts."

large field of view, but without refracting or reflecting components. The solution they devised was a camera with a coded aperture made of many openings in a pattern.

The aperture they proposed was a Fresnel zone plate—a pattern of 20 to 100 concentric rings. With a hundred or more rings the plate can produce images that are very good likenesses of the source. But the Fresnel plate had drawbacks. These drawbacks also characterized the other coded apertures, such as random pinhole arrays, developed during the '60s and '70s. In the late 1970s Ed Fenimore (P-4) and Mike Cannon (M-5) developed patterns called uniformly redundant arrays (URAs), which eliminated the shortcomings of earlier apertures.

A camera with a URA has several desirable features. Its mosaic-like aperture allows for a larger field of view without a large increase in the size of the detector. It not only provides high resolution, but accurate intensity information as well without producing any "ghosts." (Ghosts, like those fuzzy images that appear on a TV screen with poor reception, are a basic drawback to coded aperture imaging with Fresnel zone plates or random arrays.)

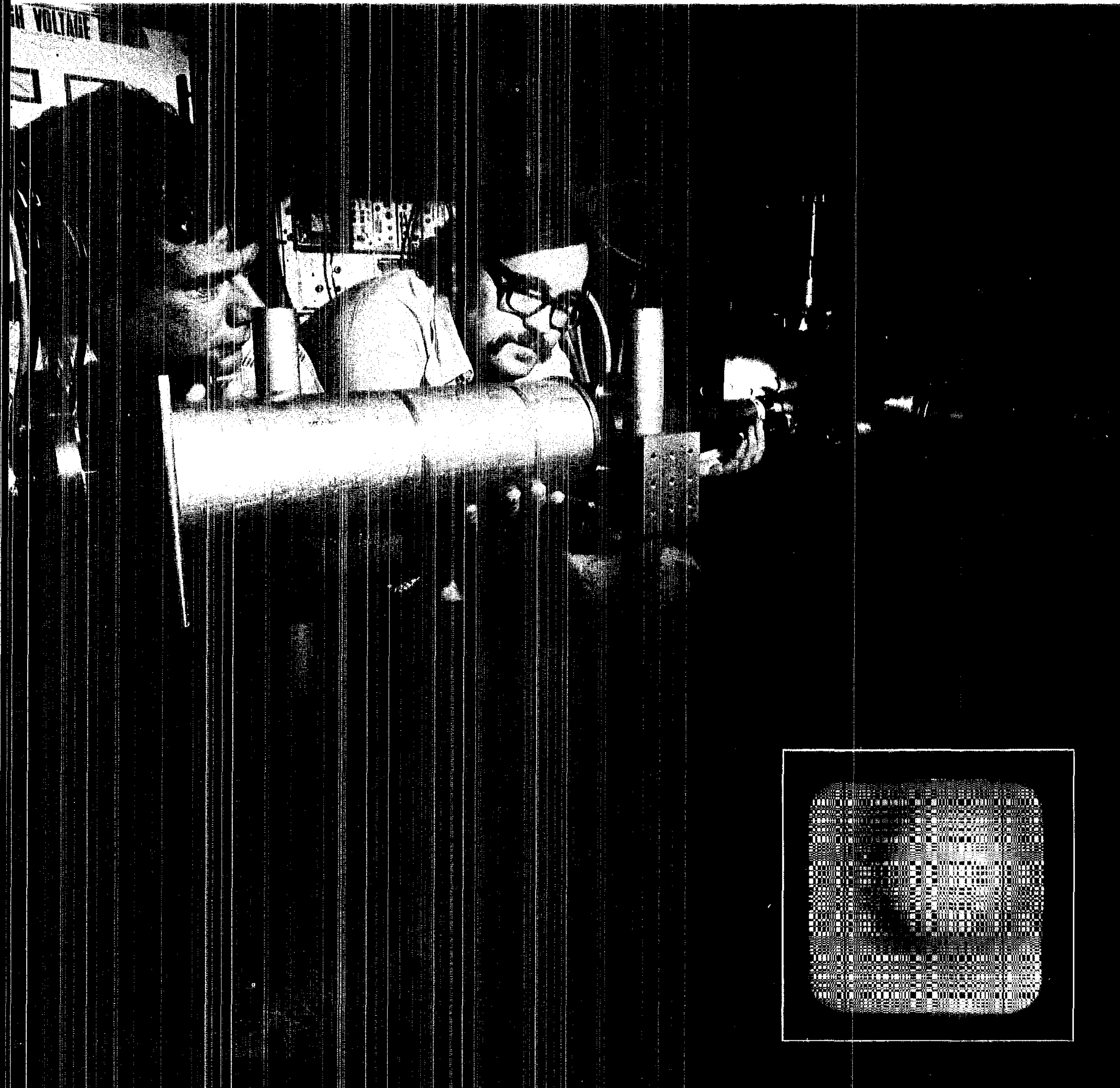
The Laboratory's Shops Department has built several prototypes to demonstrate the capabilities and advantages of URA systems. One, built for the nuclear safeguards program, is designed to image high-energy X-rays (or gamma rays). Because film is insensitive to high-energy X-rays, a medical X-ray detector (an Anger camera) was used. The aperture for the detector, designed and produced at the Laboratory, was a sheet of lead, 1/4 inch thick and about 10 inches square punctured with 1,798 pinholes, each about 0.16 inches square.

The coded-aperture detector was tested against a single pinhole detector in an experiment that imaged a pellet of plutonium-239 and a disk or uranium-235. The objects could not be discerned in the picture produced with the single pinhole, but in the URA reconstructed image, both X-ray sources can be distinguished and their size, spacing and intensities can roughly be measured.

Another prototype URA camera was built and tested for the laser fusion diagnostic group, L-4. The aperture was a thin sheet of nickel foil (0.00072 inches thick), about the size of a postage stamp, pierced with 38,086 pinholes, each about 1/8 the diameter of a human hair.

The URA camera is an aluminum box resembling a rectangular funnel with the coded aperture positioned at the small, front end and a sheet of X-ray-type film at the back. It was tested against a single pinhole camera for imaging a glass microballoon filled with deuterium and tritium, isotopes of hydrogen. The microballoon, supported on a stalk, was compressed and heated by light from two carbon dioxide lasers in the target chamber of Gemini, a two-beam carbon dioxide laser system at the Laboratory.

The experiment showed that the URA image recorded 7,100 times more X-rays than the single-pinhole image. "With such a large increase in signal strength," Fenimore said, "the URA camera will be suitable for use in experiments where the camera must be far enough away from the source to avoid damage from fusion



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lebris or at energies where the intensity of the radiation is too low for conventional pinhole techniques."

Fenimore and Cannon, who were ecently awarded a patent for the uniformly redundant array, have designed a new URA camera for laser fusion diagnostics. Still to be tested, the nstrument (built by the Shops Department) has an aperture window described by Cannon as "smaller than the ip of your little finger." It has a motorized ilm advance so that it can take many mages before researchers have to eopen the target chamber to reload the camera.

"And its resolution of six microns is state-of-the-art," said Cannon. The resolution of the prototype was 25 microns.

The method for decoding coded aperture pictures is somewhat similar to enhancing blurred images. Inside the computer, the coded image is decoded by mathematically passing the image back through the coded aperture.

"In other words," explained Cannon, "the recorded image, when correlated with a second URA pattern in the computer, yields essentially a pinhole image. But by going this roundabout way, we get a better image than what we would get from a single pinhole."

Any endeavor to which information can be obtained from an image is a candidate for image processing. With such a broad range of applications, the group operates under a broad charter.

"The basic goal of the image processing work conducted by the group," says Breedlove, "is to improve picture quality and make it more useful as scientific data. We've been aiming at building a more versatile image processing system."

***Above:** Patterns called uniformly redundant arrays are placed in cameras to provide high resolution without "ghosts." Here David Van Hulsteyn and Stephen Whitehill, both from group L-4, use such a camera; its pattern is shown inset.*

years ago

10

Plutonium lung counter

Until recently there has been no truly accurate method to directly measure the lung burden of the radioactive element plutonium. Phil Dean, H-4, has designed a counter which promises to do the job. The highest permissible body burden is 16 nanocuries of plutonium, which may stay in the lungs if inhaled but may not show up in a urine test. The counter can see one nanocurie of plutonium-238, three nanocuries of plutonium-239, and can identify americium-241. These are the three isotopes of most concern.

Satellite mini-thrust

Man-made satellites have become more sophisticated in design and use since the late 1950s, when each launch was accorded daily media reports on when it could be seen. To periodically correct satellite locations and orient antennas toward earth, small engines called thrusters are needed. Presently fueled by chemicals, satellites will need better thrusters in the future. One, the size of a grapefruit, has been under development here for 1½ years. The N-Division work is expected to be completed by next summer, according to Joe Neudecker of N-7 and Ken Cooper of N-3. The mini-thruster should operate efficiently for seven years.

20

Electric meters arrive

Los Alamos residents in all but six housing types will be billed for metered electricity beginning in April, the local AEC office announced. Meters are now being purchased and installation should be completed by January. Charges will include a two percent "tax equivalent" to equal the sales tax paid by Albuquerque residents. The change to meters was attributed to increased electrical use by the community as a whole, and to the disparity in use between individual families.

Van de Graaff planned

Facilities for low energy nuclear physics research will be modernized with the installation of a 14-million-volt tandem Van de Graaff accelerator, the first with energies this high. It will be teamed with the present 8-million-volt vertical Van de Graaff so the machines could be used separately or together, providing singly-charged particles with energies up to 23 million electron volts. The three-year project calls for an expenditure of $3.5 million. Joe McKibben, P-9 group leader, is responsible for designing modifications.

30

Airmail letter by train

An airmail letter was sent to Tucumcari and finally arrived circuitously. The reply from the postmaster followed a complaint:

"The error occurred as follows: Mail addressed to Tucumcari, New Mexico, is dispatched from here in a pouch addressed to Amarillo-Albuquerque Tr. 106, destination point Albuquerque, which office in turn makes a direct tie to Tucumcari. This office does not have a direct tie to Tucumcari because there isn't enough mail addressed to that town from Los Alamos. Therefore, the mistake in missending this particular letter to Hot Springs, New Mexico, was probably done by a railway clerk at the Amarillo-Albuquerque Train 106 at Albuquerque.

"Your memorandum and envelope together with a copy of this letter will be sent to the Superintendent of Railway Mail Service located at Albuquerque, New Mexico, for further consideration, which office has jurisdiction on such cases. I am sure this office will take immediate action to prevent such discrepancies."

Taken from files of Los Alamos News, LASL Community News, and The Atom.

etc.

A new program designed to recognize scientific excellence has been established by Director Donald M. Kerr. Provision is made for the rank of Fellow to qualified technical staff members. Fulltime employees who become Fellows will be given freedom to devote the major part of their time to research topics of their choice. Their job will be to produce fresh ideas and research initiatives that will further the Laboratory's contributions to national defense, arms control commitments and a secure energy supply. Appointments will usually be recognized with a merit pay increase.

Scientist Sandra Zink was the keynote speaker at the New Mexico Tech Women's Conference in Socorro. Zink, a physicist, has been instrumental in organizing the Laboratory's Women in Science, which encourages young women to pursue careers in science, mathematics, and engineering.

The first Laboratory building to take practical advantage of strictly passive solar heating is being constructed for AP-Division. The 5,000-square-foot structure for the Laser Induced Chemistry Laboratory will cost $345,000. It will house two laboratories, four offices and a large experimental area. The sun is expected to provide 65 percent of the space heating needs.

Reduction-in-force notices for 10 employees in G-Division and for one employee in CNC-Division were announced late in October. They stem from funding cuts, particularly with the National Uranium Resource Evaluation program. Part of this involved work in surveying streams and other water sources for indications of natural uranium deposits in four Rocky Mountain states and Alaska.

The third annual Hot Dry Rock Geothermal Information Conference was hosted by the Laboratory in Santa Fe in October and involved about 300 people from around the world. The same week, the LAMPF accelerator Users Group held its 14th annual meeting in Los Alamos, drawing 200 researchers.

patents

Patent 4,209,780 or "Coded Aperture Imaging with Uniformly Redundant Arrays" was granted to Edward E. Fenimore and Thomas M. Cannon, both of Los Alamos. The abstract states that this system uses uniformly redundant arrays to image non-focusable radiation. Virtually limitless signal-to-noise ratio is obtained with high transmission characteristics.

Patent 4,211,954 or "Alternating Phase Focused Linacs" was granted to Donald A. Swenson of Los Alamos. The abstract states that a heavy particle linear accelerator employs radio-frequency fields for transverse and longitudinal focusing as well as acceleration. A beam of particles is contained without additional magnetic or electric focusing fields.

Patent 4,213,836 or "Laser-Induced Separation of Hydrogen Isotopes in the Liquid Phase" was granted to Samuel M. Freund, William B. Maier II, Willard H. Beattie and Redus F. Holland, all of Los Alamos. The abstract states that hydrogen isotope separation is achieved by either dissolving a feedstock compound in a liquid solvent or by liquefying such a compound. The liquid phase can be irradiated with monochromatic radiation of a wavelength which at least preferentially excites those molecules of the feedstock containing a first hydrogen isotope. A photochemical reaction is induced in the excited molecules and the reaction product, containing the first isotope, is separated from the liquid phase.

short takes

among our visitors

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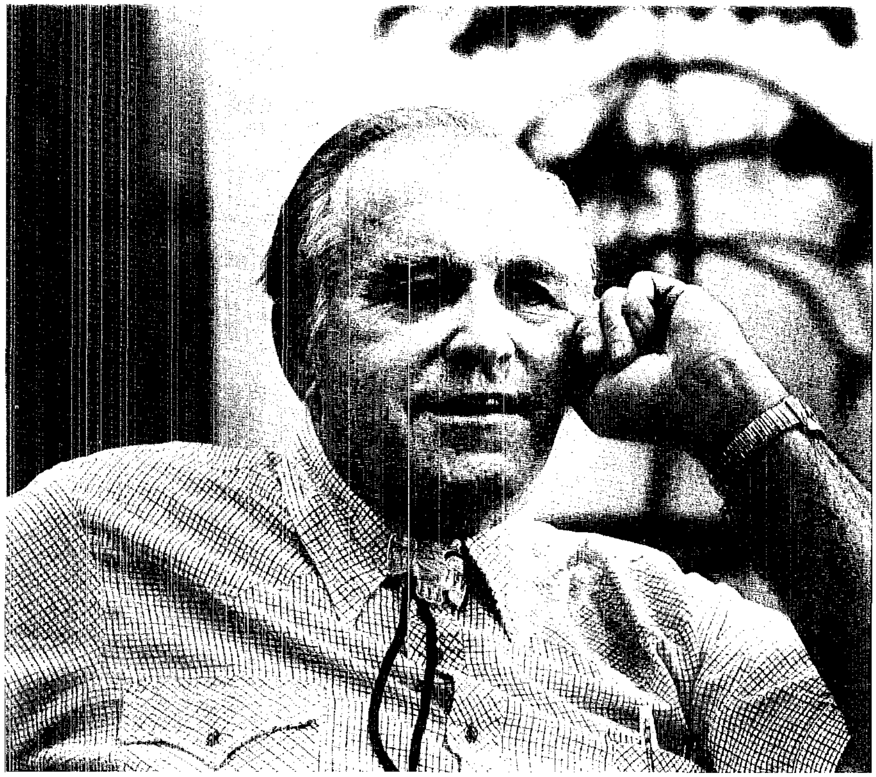

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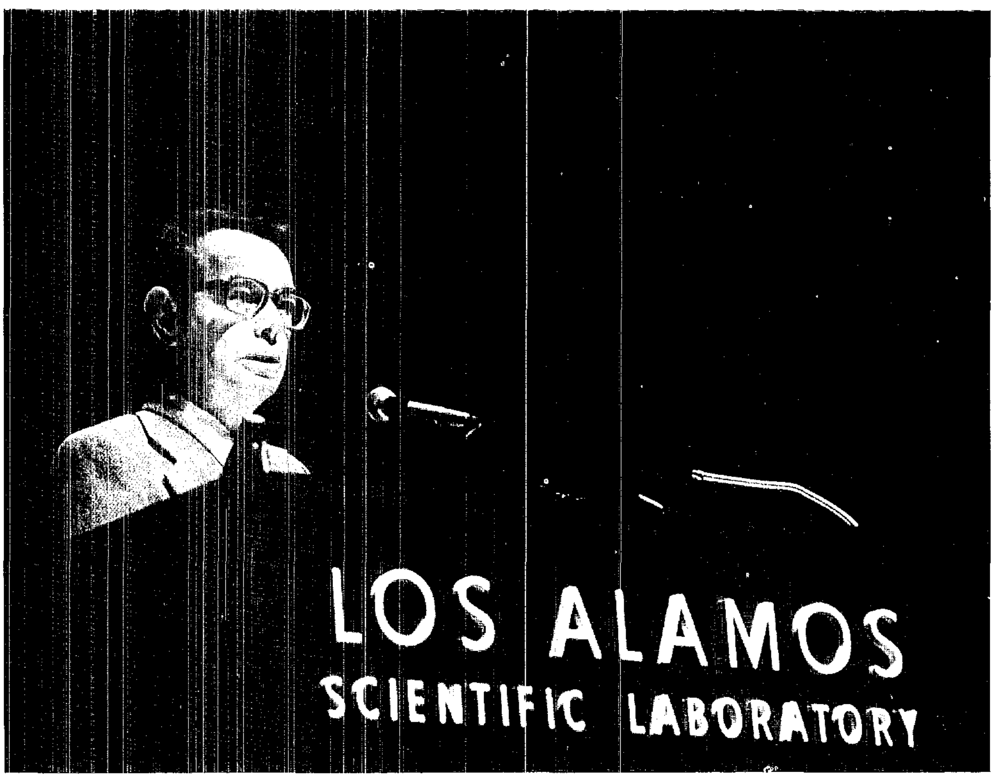
__Above:__ Charles O. Prindle, rear admiral in the U.S. Navy, was in Los Alamos for talks on defense systems. He presently reports to the Office of the Chief of Naval Operations as director of the undersea and strategic warfare and nuclear energy development division.

__Above right:__ Frank L. Brannigan directed a course in fire loss management for Laboratory and Department of Energy employees here. Brannigan, in the fire management field since 1942, feels that fires will occur and that building systems can minimize their impact. He is a consultant and a professor of fire science programs at Montgomery College.



John Flower

__Right:__ Donald E. Graves, specialist with the U.S. Department of State, spoke on the Soviet Politburo and foreign policy decisions during a visit to Los Alamos. Graves holds a master's degree in Russian history from Harvard and has served 28 months in the Soviet Union for the Department of State.

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